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# WORKING PAPER NO. 131

# *Labor market time and home production:*

## *A new test for collective models of intra- household allocation*

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**March 2005**

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# *Labor market time and home production:*
## *A new test for collective models of intra- household allocation*

**F. Bourguignon[*] and M.C. Chiuri[#]**

**Abstract**

The allocation of time is a crucial decision that influences many aspects of household welfare, above all consumption, income level and home production. This paper presents a new methodology to estimate woman domestic productivity using a French time use survey, at least whenever the recursivity property for constrained utility maximization with home production applies.
It provides empirical evidence not rejecting a collective model of household decision making over working time, as the sum of time spent in domestic production and market labor time. Our results show also that female domestic productivity is a relevant variable explaining intra-household distribution of resources.

**JEL classification**: D13, J22.
**Keywords**: Collective models, home production, time- use

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## Contents

## 1. Introduction

The allocation of time is a crucial decision that influences many aspects of household welfare. On one side, the way household members allocate their time among various economic activities is an important determinant of the level of household income. For instance, low income households devote large amounts of time to activities such as cooking or sewing in order to meet the basic needs of their members.

On the other side, time use by household members might well be affected by the distribution of income and “spending power” within a household.

In the most recent economic literature, the issue of intra-household decisions has been deeply analysed by collective models since the pioneer work of Chiappori (1988). The basic model sees each household as characterised by a pre-defined distribution of "spending power" (and so utility distribution) between its members; it uses this to set income transfers within the household and then each family member determines their own private consumption and leisure by maximising individual preferences subject to a post-transfer individual budget constraint. This achieves Pareto efficient allocations within a household. Using this framework, testable restrictions can be derived and the household specific sharing arrangements (the so called “income sharing rule”) can be retrieved up to an additive constant.

Several empirical applications and hypothesis testing have been produced (among others, Fortin and Lacroix, 1997, Chiappori, Fortin and Lacroix, 2002, and Blundell R., Chiappori P. A., Magnac T. and Meghir C., 2001) and they are all consistent in not rejecting the collective view of intra-household decision, using mainly data on individual labor supply of two-earner households.

However, given the paucity of time use surveys, they make a strong assumption: i.e. that all time not spent on the labor market is pure leisure, with positive effects on individual preferences; in other words they exclude time devoted to domestic work like home production or child care. Thus, the drawback of the literature produced so far is an unsatisfactory measure for pure leisure (see the critique addressed in Apps and Rees, 1997). Such a framework could easily provide a biased evidence on the within household decision process as lower female labor market hours would be equated to a larger share of the household’s full income according to a predefined “sharing rule”. The reality instead might be that also home production time is traded for monetary income, as domestic production accounts for more than half of the time devoted by a woman to economic activities.

From a theoretical perspective Chiappori (1997) extends the basic model to home production and proves that under certain hypotheses still the intra-household distribution of resources can be recovered up to a constant. In particular, he shows that results differ according to whether or not the domestic good is substitute for market goods. In the first case, the price for domestic goods is exogenously fixed at the market level, and when the production function shows constant returns to scale, it is possible first to retrieve the production function up to a multiplicative constant, and then the income sharing rule up to an additive constant. Alternatively, the price of domestic good is an endogenous piece of information; however, the retrieval of the production function with constant return to scale still allows to identify the income sharing rule, although up to an additive function of individual wages.

More recently, availability of time use surveys raised the interest in the estimation of household model with domestic production. In particular, Aronsson, Daunfeldt and Wikstrom (2001) develop and test a collective model on a sample of Swedish households; however, the system of leisure demands is estimated with a home production specified in reduced form. The same drawback is in Rapoport, Sofer and Solaz (2003) which provides evidence from France.

In this paper we discuss the relevance of fully specifying a household model in which decisions are taken with respect to consumption, leisure, market working time and time devoted to home production. The framework chosen is such that household welfare is affected by the distribution of individual capacities to produce income and to provide domestic goods and services.

The innovative contribution of the paper is threefold:

(a) we develop a new technique that allows to estimate women domestic productivity when only the use of time is observed, and we provide an application to a French time use survey;

(b) we investigate intra-household allocation of “total” (market and domestic) work;

(c) we test the collective model when home production is taken into account explicitly.

The rest of the paper is organised as follows. Section 2 introduces the theoretical framework and presents the assumption necessary to identify domestic productivity. In Section 3 we choose a functional form for home production and specify the estimation framework. Section 4 presents the testing strategy on the total labor supply. The main characteristics of the sample of French households are reported in Section 5. Finally, results obtained from the empirical estimation of the model are contained in Section 6 and Section 7 concludes.

## 2. A collective household model with home production

As in a standard framework, we consider individual preferences defined over consumption of a composite good $C_i$ (with *i=m, f*) and pure leisure $l_i$. The budget constraint defines total household income as the sum of labor and non labor incomes and the monetary value of home production. In such a framework, we define the problem of household welfare maximization as the following:

$$\begin{aligned} &\max_{C_m, C_f, l_m, l_f} \theta U_m\left(C_m, T_m - h_m - t_m\right) + (1-\theta) U_f\left(C_f, T_f - h_f - t_f\right) \\ &s.t. C_m + C_f \le y + w_m t_m + w_f t_f + Q\left(g_m\left(h_m, \pi_m\right), g_f\left(h_f, \pi_f\right)\right) \end{aligned} \tag{1}$$

where in (1) $T_i - t_i - h_i = l_i$ since individual leisure $l_i$ together with time for home production $h_i$ and labor market time $t_i$ adds up to $T_i$, the individual total time endowment. In problem (1) the price for composite good $C_i$ is normalised to 1 and *Q(.)* is a household production function separable in the two individual arguments, i.e. the individual time devoted to home production and individual domestic productivity $\pi_i$.

One could argue that, although quite general, model (1) disregards direct positive effects on individual utility coming from working time on job or at home. That is because in (1) only time for pure leisure and direct consumption increase individual utility. However, such an assumption is less stringent than first thought, since we do not consider child care as domestic production and define total time endowment $T_i$ net of time devoted to child care. As a consequence, our results, presented under the assumption of egoistic preferences, easily extend to preferences separable in an argument capturing altruism for children's quality of life.

In (1) $\theta$ is a weighting factor assigned to individual preferences taking a value in the closed interval [0,1]. According to two opposite views in the literature, two alternative assumptions can be made on $\theta$. If it is a constant term, then problem (1) can be inserted in the traditional "unitary" approach to household decision modelling. However, the main critique addressed to this type of models is that they disregard intra-household decision making.

A more general model is the "collective" model[1], where $\theta$ is a function of exogenous attributes, such as non labor income *y*, individual wage rates $w_i$ and *distributional factors* $\boldsymbol{\kappa}$, i.e. $\theta = \theta(y, w_m, w_f, \boldsymbol{\kappa})$. The paper by Chiappori, Fortin and Lacroix (2002) (CFL henceforth) provides various examples of distributional factors, as the divorce laws, or the so-called sex ratio, that is the relative scarcity of women compared to men, or the share of non labor income under control by one spouse and defines them as "variables that can affect the intra-household decision process without influencing individual preferences or the joint consumption set"(see p.3).

The point we raise in this paper is that individual domestic productivity $\pi_i$ could well determine the decision process over home production, but also could partly explain the intra-household allocation process over time and consumption, as it might directly affects $\theta$. If we will find enough evidence not to be able to reject the null, then the same will be also a sufficient evidence against the standard unitary framework.

Solving out problem (1) proves that optimal decisions over time use depends on preferences, technology in the production activity and exogenous income variables. Whenever the marginal productivity of domestic labor time at zero is larger than the individual market wage rate, then it is efficient for the household member to participate to the labor market and considers to spend some positive amount of time for domestic activities. In such a case, from previous literature[2] we know that problem (1) satisfies the *recursivity property* for interior solutions, that is, whenever $t_i > 0$ and $h_i \geq 0$,

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[1] See Browning and Chiappori (1998) or Browning, Chiappori and Lechene (2004)

[2] See Singh, Squire and Strauss (1986), the first study to insist on this property for agricultural households, but also Chiappori (1997) or Udry (1996).

problem (1) can be solved in two-stages. In particular, defining $L_i = t_i + h_i$ as total labor time, (1) can be re-written as the following:

$$\begin{aligned}
&\max_{C_m, C_f, l_m, l_f} \theta U_m\left(C_m, T_m - L_m\right) + (1-\theta) U_f\left(C_f, T_f - L_f\right) \\
&s.t. C_m + C_f \le y + w_m L_m + w_f L_f + P^*
\end{aligned} \tag{2}$$

where $P^*$ is the solution to the profit maximization problem:

$$P^* = \max Q\left(g_m\left(h_m, \pi_m\right), g_f\left(h_f, \pi_f\right)\right) - w_m h_m - w_f h_f \tag{3}$$

Note that in (3) the price of the domestic composite good has been normalised to *1*, under the assumption that the output *Q(.)* is a substitute for market goods (*marketable domestic good*)[3].

A first result this paper aims to achieve is the estimation of individual domestic productivity, whenever the recursivity property applies. Take the first order condition of problem (3) with respect to $h_i$, i.e.:

$$w_i = Q_{g_i} \frac{\partial g_i\left(h_i, \pi_i\right)}{\partial h_i} \tag{4},$$

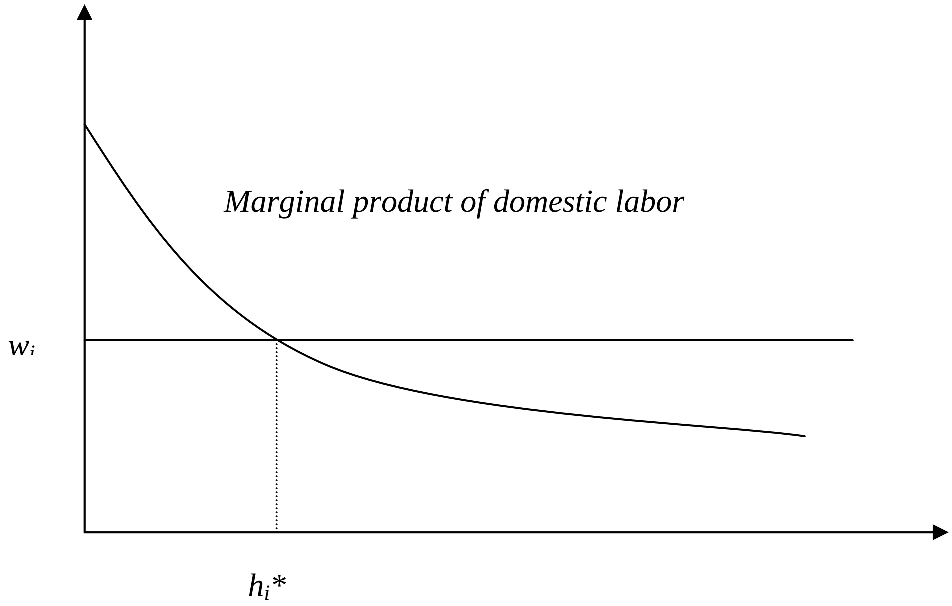
also reproduced in Figure 1. If member $i$ works more than $h_i^*$ then he/she will be working both on the market and at home. Although we know that the total number of working hours depends on preferences as well as on income variables, including the other spouse's wage, nevertheless, due to the separability property between problems (2) and (3) the optimal redistribution of working time between home production and paid work is only affected by individual domestic productivity and his/her market wage.

Denoting $g_h$ as the first derivative of $g$ with respect to $h_i$, under the assumption of monotonicity for $Q(\cdot)$ and $g(\cdot)$, both functions $Q_{g_i}$ and $g_h$ can be inverted and condition (4) can be solved for $h_i$, as the following:

$$h_i = \frac{g_h^{-1}\left(w_i, \pi_i\right)}{Q_{g_i}} \tag{5}.$$

[3] As shown in Chiappori (1997), this rather plausible assumption allows to fully identify the income sharing rule up to an additive constant.

Figure 1 Optimal decision over home production time when the recursivity property holds.




As it will be clarified later, we can use condition (5) to estimate the unobservable individual domestic productivity $\pi_i$:

- as a source of heterogeneity in the relationship between domestic hours of work and the individual wage rate;
- after choosing a functional form for home production.

A further aim of the paper is the analysis of the intra-household allocation of total working time and the empirical testing for the collective model. In particular, under the assumption of egoistic or caring preferences, problem (2) is equivalent to:

$$\begin{array}{l} \max\limits_{C_i, l_i} U_i\left(C_i, T - L_i\right) \\ s.t. C_i \leq w_i L_i + \phi_i \end{array} \qquad (i=m, f) \qquad (6)$$

where $\phi_i$ is member $i$ share of total income, exogenously fixed and including home production. In other words, $\phi_i$ is the so-called "income sharing rule". In order for individual budget constraints to meet the total household income, the condition $\phi_m + \phi_f = y + P^* = \bar{y}$ has to hold.

The collective framework so far specified imposes certain restrictions on the system of total labor supply, as it will be of the following type:

$$\begin{aligned} L_m &= L^m\left(w_m, \phi_m\left(w_m, w_f, \bar{y}, \pi_m, \pi_f, \mathbf{z}\right), \mathbf{z}\right) \\ L_f &= L^f\left(w_f, \bar{y} - \phi_m\left(w_m, w_f, \bar{y}, \pi_m, \pi_f, \mathbf{z}\right), \mathbf{z}\right) \end{aligned} \qquad (7).$$

Taken ***z*** as a vector of demographic variables affecting both individual preferences and the income share $\phi_i$, in Section 4 we will show how the particular structure of system (7) imposes testable restrictions on the labor supply behavior and allows to recover the individual income sharing rule $\phi_m$ up to an additive function of ***z***, if at least one distribution factor can be observed. In particular, note that an important testable restriction has to do with the role of domestic productivities, as stated in the following remark:

***Remark 1*** *Individual domestic productivity affects a collective system of household total labor supply through two channels:*

(i) *the total non labor income* $\bar{y}$*,*

(ii) *the weighing factor* $\theta$ *(or, equivalently the income share* $\phi_i$*).*

In a standard unitary model instead, domestic productivities should have only affected total labor supply through unearned income only, which, in principle, already provides a new test of the unitary versus the collective model.

### 3. The identification of woman's domestic productivity

In the paper, we assume that the home production function has the following specification:

$$Q\left(g_m\left(h_m, \pi_m\right), g_f\left(h_f, \pi_f\right)\right) = \left(a_m h_m + \pi_m\right)^{\gamma_m} + \left(a_f h_f + \pi_f\right)^{\gamma_f}$$
$$\text{with } \gamma_i \in [0,1] \quad (i=m, f) \qquad (8).$$

The function *Q(.)* has two separable components which measures man's and woman's contribution to home production and both satisfying the property of decreasing return to scale. The additive separability hypothesis excludes cases of joint production.

Solving problem (3) under the requirement that the home production is of type (8), it is possible to find that the first order condition (FOC) leading to a positive time spent in domestic production, whenever he/she also works, is:

$$\gamma_i a_i \left(a_i h_i + \pi_i\right)^{\gamma_i - 1} = w_i \tag{9}$$

i.e. the condition of individual's marginal domestic productivity (in monetary value) equal to his/her wage rate. According to the efficient condition (9), allocating working time to home production for a given level of labor market time, would depend on both individual domestic productivity and the salary level.

As already shown in Section 2, condition (9) can be solved out to find the optimal level of time $h_i$ assigned by each individual in a couple to home production, that is:

$$\begin{cases} h_i = 0 & if \quad a_i \leq 0 \\ h_i = A_i w_i^{\left(\frac{1}{\gamma_i - 1}\right)} + B_i & if \quad a_i > 0 \end{cases} \tag{10}$$

after defining $A_i = \gamma_i^{\left(\frac{1}{1-\gamma_i}\right)} a_i^{\left(\frac{\gamma_i}{1-\gamma_i}\right)}$ and $B_i = -\dfrac{\pi_i}{a_i}$.

Substituting solution (10) into (4), we find that the optimal domestic production level is:

$$P^* = \sum_{i=f}^{m} \left(\frac{w_i}{\gamma_i a_i}\right)^{\frac{\gamma_i}{\gamma_i - 1}} \quad if \quad h_i > 0 \quad for\ i{=}m,f \tag{11}$$

Note that $P^*$ is independent of the intercept $\pi_i$ in the individual home production function. In other words, we find that for internal solutions only, the requirement of efficiency in home production implies that the system of total labor time (7) depends on the individual domestic productivity parameter $\pi_i$ only through $\phi_m(\cdot)$, fully satisfying the definition for a *distributional factor* already provided by the literature on collective models.

As far as the identification of individual domestic productivity is concerned, from condition (9) we know that $\pi_i$ could be in principle identified from the observed individual wage rate, when $h_i = 0$. Alternatively, for $h_i > 0$, $\pi_i$ can still be retrieved after introducing some heterogeneity in the model. In particular, the following steps show how the home production function can be estimated through the first order condition (10) when heterogeneity is imposed on the slope coefficient $a_i$ and on the intercept term $\pi_i$.

Introduce heterogeneity in $a_i$ by rewriting this coefficient as:

$$a_i = \bar{a}_i(1+\varepsilon_i) \tag{12}$$

where $\varepsilon_i$ is distributed as $N(0,\sigma_\varepsilon)$. Then, the hour equation rewrites as:

$$h_i = [\bar{a}_i(1+\varepsilon_i)]^{\frac{\gamma_i}{(1-\gamma_i)}} \gamma_i^{\frac{1}{1-\gamma_i}} w_i^{\frac{1}{(\gamma_i-1)}} - \frac{\pi_i}{\bar{a}_i(1+\varepsilon_i)}$$

Considering that the second term may be rather small and taking first order approximations, the home production labor supply may be re-written as :

$$h_i = \bar{A}_i w_i^{\left(\frac{1}{\gamma_i-1}\right)} + \bar{B}_i + \varepsilon_i\left[\frac{\gamma_i}{\gamma_i-1}\bar{A}_i w_i^{\left(\frac{1}{\gamma_i-1}\right)} - \bar{B}_i\right] \tag{13}$$

with $\bar{A}_i = \gamma_i^{\left(\frac{1}{1-\gamma_i}\right)} \bar{a}_i^{\left(\frac{\gamma_i}{1-\gamma_i}\right)}$ and $\bar{B}_i = -\frac{\pi_i}{\bar{a}_i}$.

Let us now introduce observed heterogeneity in $\bar{B}_i$:

$$\bar{B}_i = X_i'\beta_i + \eta_i \tag{14}$$

where $\eta_i$ is an error term, orthogonal to $\varepsilon_i$, which follows $N(0,\sigma_\eta)$ and captures also some measurement errors. Due to the recursivity property discussed in Section 2, condition (14) allows us to instrument $\pi_i$ on a vector of individual (not household) characteristics $X_i$.

Finally, putting (13) and (14) together (ignoring the product of residual terms $\varepsilon\cdot\eta$), the structural form for individual home production time becomes:

$$h_i = \overline{A}_i w_i^{\frac{1}{\gamma_i - 1}} + X_i{}'\beta_i + \varepsilon_i \left[ \frac{\gamma_i}{\gamma_i - 1} \overline{A}_i w_i^{\frac{1}{\gamma_i - 1}} - X_i{}'\beta_i \right] + \eta_i \quad (15).$$

Model (15) is non -linear in $\gamma_i$. It also exhibits heteroskedasticity with some restrictions linking the expected value of $h_i$ and the standard deviation of the error terms. Therefore, equation (15) could be estimated using maximum likelihood techniques (ML). The derivation of the log likelihood function is reported in Appendix 1.

Using definition (14), the fitted value of $\pi_i$ will be given by the condition:

$$\hat{\pi}_i = \hat{\overline{a}}_i \cdot (X_i{}'\hat{\beta}_i) \quad (16).$$

**4. The testing strategy on the household total labor supply**

Although testing for the relevance of individual domestic productivity in the household labor supply might already provide a preliminary evidence against the traditional unitary model, it is yet not sufficient as a test for the collective model. As shown in CFL and other studies, it is the way in which the distribution factor $\pi_i$ and the spouse' wage rate do affect the two labor supplies that enables us to test for a general collective model of labor supply.

Following CFL (their *Proposition 3)*, we can derive a set of necessary conditions for any pair of $(L_m, L_f)$ to be the solution of problem (6) for a given sharing rule $\phi_m$. CFL show that observing one distribution factor and the individual wage rates is sufficient to impose a set of testable restrictions for a collective model on a system of labor supply and to recover the partials of the sharing rule with respect to total non labor income, each individual wage rate and the distribution factors $\pi_i$.

Thus, in order to derive a series of parametric tests, we compare the collective approach with an unrestricted system of household labor supplies, in line with the testing strategy developed in CFL. However, the novelty here stays in the fact that, for the first time, we apply it to a system of total labor supply $(L_m, L_f)$ as the sum of market working time and time devoted to domestic activities as solution of problem (3).

In order to provide testable restrictions for the collective model as earlier specified, consider the following household labor supply system:

$$L^m = f_0 + f_1 \log w_m + f_2 \log w_f + f_3 \bar{y} + f_4 \log w_f \cdot \log w_m + f_5 \log w_m \cdot \bar{y} + f_6 \log w_f \cdot \bar{y} + f_7 \pi_f + f_8 \pi_m + f_9 '(\mathbf{z})$$

$$L^f = m_0 + m_1 \log w_m + m_2 \log w_f + m_3 \bar{y} + m_4 \log w_f \cdot \log w_m + m_5 \log w_m \cdot \bar{y} + m_6 \log w_f \cdot \bar{y} + m_7 \pi_f + m_8 \pi_m + m_9 '(\mathbf{z})$$

(17)

System (17) has a semi-log functional form, as the one used by CFL, but more general in the sense that it allows more interactions in the variables. We call it *unrestricted* because no cross-equation restrictions are imposed; however, it does provide the nesting framework to test for a collective model[4].

Following CFL, we retrieve the necessary conditions for system (17) to be derived from a collective framework and we obtain three equality restrictions:

$$\frac{f_4}{m_4} = \frac{f_5}{m_5} = \frac{f_6}{m_6} = \frac{f_7}{m_7} = \frac{f_8}{m_8} \tag{18}$$

Note that if restrictions (18) are satisfied, then the income sharing rule parameters can be identified up to a constant, as the partials of $\phi_m$ are respectively:

$$\frac{\partial \phi_m}{\partial \bar{y}} = \frac{m_5 \left( f_3 + f_5 \log w_m + f_6 \log w_f \right)}{\Delta}$$

$$\frac{\partial \phi_m}{\partial \pi_f} = \frac{m_7 f_5}{\Delta} \tag{19}$$

[4] Although we disregard in this paper testing for the *unitary model*, still the framework could have handled it. In particular, if we were in a unitary model, whenever each spouse is favourable to participate to the labor market and to produce domestic goods, the household labor supply system (including both market and non-market working time), satisfies two sets of restrictions; they are the necessary and sufficient conditions for a household utility function to be maximised, subject to a household budget constraint:

a) the Slutsky matrix must be symmetric and positive semi-definite;

b) a further set of condition is due to the irrelevance of individual domestic productivities in the decision process.

These conditions translate into the following testable sets:

a) the Slutsky matrix of compensated wage effects is symmetric and positive semi-definite if, either:

$f_2 = f_3 = f_4 = f_5 = f_6 = 0$; $\quad m_1 = m_3 = m_4 = m_5 = m_6 = 0$;

when the system of total labor supply depends on own wage and preference factors, or:

$f_1 = f_2 = f_4 = f_5 = f_6 = 0$; $\quad m_1 = m_2 = m_4 = m_5 = m_6 = 0$;

if it depends on total non-labor income and preference factors;

b) irrelevance of individual domestic productivities in the unitary decision process implies that:

$f_7 = m_7 = 0$.

$$\frac{\partial \phi_m}{\partial \pi_m} = \frac{m_8 f_5}{\Delta}$$

$$\frac{\partial \phi_m}{\partial w_m} = \frac{f_5\left(m_1 + m_4 \log w_f + m_5 \bar{y}\right)}{w_m \Delta}$$

$$\frac{\partial \phi_m}{\partial w_f} = \frac{m_5\left(f_2 + f_4 \log w_m + f_6 \bar{y}\right)}{w_f \Delta}$$

where $\Delta = m_5 f_3 - f_5 m_3$. Integrating the four differential equations system in (19) we can obtain the income sharing rule equation:

$$\begin{aligned}\phi_m = \frac{1}{\Delta}\big[& m_5 f_3 \bar{y} + m_1 f_5 \log w_m + m_5 f_2 \log w_f + m_7 f_5 \pi_f + m_8 f_5 \pi_m + m_5 f_5 \log w_m \bar{y} + \\ & + m_6 f_5 \log w_f \bar{y} + m_4 f_5 \log w_m \log w_f \big] + \tau\end{aligned} \tag{20}$$

in (20) $\tau$ is an additive function of $(\mathbf{z})$.

Finally, note that the system of total labor supply associated with a collective setting is:

$$\begin{aligned} L_m &= \alpha_1 \log w_m + \alpha_2 \phi_m + \alpha_3 \\ L_f &= \beta_1 \log w_f + \beta_2\left(\bar{y} - \phi_m\right) + \beta_3 \end{aligned} \qquad (21).$$

where $\alpha_1 = \left(m_1 f_5 - f_1 m_5\right)/ m_5$; $\alpha_2 = \Delta / m_7$; $\beta_1 = \left(m_2 f_5 - f_2 m_5\right)/ f_5$; $\beta_2 = -\Delta / f_5$.

For the sake of completeness, the functional form in (21) can be obtained solving an individual utility maximization problem, where preferences have an exponential indirect utility form (see Stern, 1986) as the followings:

$$\max \frac{\exp\left(\alpha_2 w_m\right)}{\alpha_2}\left(\alpha_2 \phi_m + \alpha_3 + \alpha_1 \log w_m\right) - \frac{\alpha_1}{\alpha_2}\int_{-\infty}^{\alpha_2 w_m} \frac{\exp(t)}{t} dt \tag{22}$$

and

$$\max \frac{\exp\left(\beta_2 w_f\right)}{\beta_2}\left(\beta_2 \phi_f + \beta_3 + \beta_1 \log w_f\right) - \frac{\beta_1}{\beta_2}\int_{-\infty}^{\beta_2 w_f} \frac{\exp(t)}{t} dt \tag{23}$$

and system (21) can be derived applying Roy's identity $\frac{V_{w_i}}{V_{\phi_i}} = L(w_i, \phi_i)$ (with $i$=$m$ ,$f$) and taking $\phi_f = \bar{y} - \phi_m$, in order to meet the household budget constraint.

## 5. Sample selection and description

The data-set used in this study is the INSEE (1999) survey Enquête Emploi Du Temps 1998-99, which is the broadest experiment ever conducted in France of data collection for household time use. It includes information on main demographic characteristics, labor supply, incomes and use of time for a sample of 8,186 French households (20,370 individuals). Data on the use of time were collected for household members 15 years old or older (15,441 individuals in 7,949 households); they received and filled a booklet reporting information on the use of time in minutes in a weekly day. The potential of the survey is clear-cut once it is compared with a previous time use survey by INSEE, collected in 1986, which had the limit of providing time use information on one member per household, rendering it useless for our study.

Being interested in analysing couple's time allocation process, we only consider households whose head lives in couple (corresponding to 64.75 percent of the total sample). Moreover, we also select those households with head and spouse being 25-60 years old. As our framework does not raise retirement and unemployment issues, we exclude households with couple members being either retired or unemployed; moreover, under the assumption that income variables might not be reliable, we do not consider families with head or spouse being self-employed.

To begin with, we disregard use of time on holidays or during the weekend, as time use in spare time might be driven by significantly different purposes. Therefore, a further selection (2,482 households, about 56 percent of the selected sample) considers family members interviewed in working days only. Later on, however, as a sensitivity analysis, we empirically test whether our approach extends to the allocation of time over the weekend.

Finally, 31 percent of the selected sample reported missing income variables, and as a consequence were disregard them. Thus, the final sample of our study has 674 observations and its main characteristics are reported in Table 1.

Table 1 Descriptive statistics for couples

| | no. | mean | std. dev. |
|---|---|---|---|
| (1) Household Characteristics | | | |
| Household without children (a) | 166 | 0.25 | |
| Number of children: (a) | 508 | 2.00 | 1.02 |
| Geographical area: | | | |
| North | 674 | 0.08 | |
| East | 674 | 0.12 | |
| Central-east | 674 | 0.10 | |
| Centre | 674 | 0.24 | |
| Parisian Region | 674 | 0.13 | |
| West | 674 | 0.18 | |
| South-west | 674 | 0.10 | |
| Mediterranean | 674 | 0.10 | |
| Home- ownership status | 674 | 0.63 | |
| Total weekly unearned income (b) (c) | 674 | 79.99 | 185.69 |
| (2) Men Characteristics | | | |
| Age | 674 | 42.34 | 9.10 |
| Education: Primary school | 674 | 0.25 | |
| Secondary school | 674 | 0.13 | |
| Univ. and post-grad. Degrees | 674 | 0.27 | |
| Employment Characteristics: Participation | 674 | 0.91 | |
| Weekly contract hours of work | 612 | 37.95 | 4.89 |
| Net hourly wage (b) | 612 | 10.03 | 6.35 |
| (2) Women Characteristics | | | |
| Age | 674 | 39.99 | 8.73 |
| Education: Primary school | 674 | 0.27 | |
| Secondary school | 674 | 0.16 | |
| Univ. and post-grad. Degrees | 674 | 0.28 | |
| Employment Characteristics: Participation | 674 | 0.64 | |
| Weekly contract hours of work | 432 | 33.34 | 9.25 |
| Net hourly wage (b) | 432 | 8.31 | 4.89 |

Note: (a) the number of positive observations only is reported.

(b) Nominal variables in Euro

(c) Unearned income is a derived variable from total household income net of couple’s labor income.

In the survey the description provided for each line of activity is very accurate: it contains duration, place and activity type (classified in about 90 codes). Following INSEE (2000) we recode the reported activities into six main categories:

a) personal time,
b) domestic time,
c) child care,
d) market working time,
e) travel time,
f) leisure.

To give a flavour of the contents of each category we provide some examples of activity for each of them. Personal time includes sleeping, self-care, private activities or eating; home-production time adds up minutes spent in cooking, cleaning, sowing, washing, doing shopping or gardening. The category of child care includes time spent playing with children whereas market working time comprises paid work also if done at home, training, learning and time breaks. Leisure considers various types of entertainment as sports, reading, cinema, listening music, watching TV, relaxing, and social activities as voluntary work, religious practices and telephone conversations.

Although two activities (main and secondary) could have been reported in the booklet whenever more than one was performed at the same time, we restrict our analysis to main activities only, as the secondary activity is not frequently mentioned.

Table 2 contains some descriptive statistics on the percentage of time devoted to each activity in a day for each spouse. Adding up market work, home production and child care, women spend more time than men working. Note also that men devote most of their working time on the job, whereas time is almost equally shared between paid and unpaid work for women.

Child care only apparently seems not to be playing a relevant role. Restricting the analysis to the sample of young households with at least one child 0-3 years old (116 households) women spend more than 10 percent of their time exclusively taking care of their children.

Another interesting picture concerning time use comes out of Table 3 which contains the statistically significant correlation matrix across spouses activities. As we could expect, there is a high complementarity in working time between spouses, proven not only by a positive correlation (0.2) between their market working time but also by a negative correlation between individual leisure and partner's working time. Similarly individual leisure is also positively correlated with the spouse one. There is instead no evidence of joint domestic production (consistent with our assumption of separability in the production function), rather women time for home production is positively correlated with men's leisure.

Table 2 Couple's time use

| | mean | std. dev. |
|---|---|---|
| Men daily time use (in percent) | | |
| Duration of personal time | 0.44 | 0.08 |
| Duration of market working time | 0.31 | 0.12 |
| Duration of home production time | 0.06 | 0.07 |
| Duration of leisure | 0.13 | 0.09 |
| Duration of travel time | 0.05 | 0.04 |
| Duration of child care | 0.01 | 0.02 |
| Women daily time use (in percent) | | |
| Duration of personal time | 0.43 | 0.07 |
| Duration of market working time | 0.20 | 0.16 |
| Duration of home production time | 0.19 | 0.12 |
| Duration of leisure | 0.11 | 0.08 |
| Duration of travel time | 0.04 | 0.04 |
| Duration of child care | 0.03 | 0.06 |

Note: Each distribution refers to the selected sample of 674 households.

Table 3 Correlation indexes across spouses' use of time

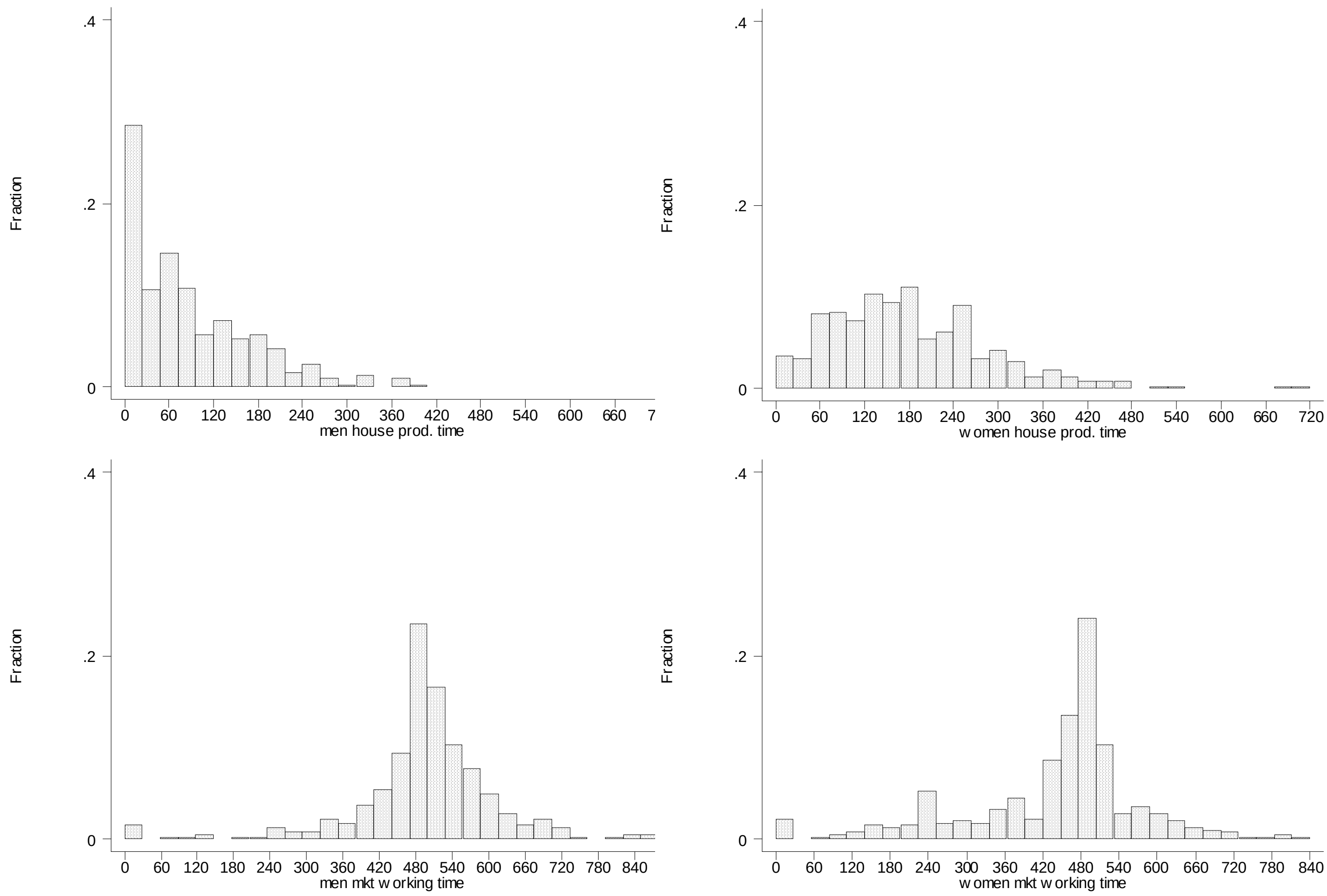
| MEN<br>WOMEN | *Market working time* | *Home production time* | *Leisure* |
|---|---|---|---|
| *Market working time* | 0.197 * | - | -0.223 * |
| *Home production time* | - | - | 0.091 |
| *Leisure* | -0.205 * | - | 0.350 * |

Note: Only correlation indexes significant at the 95% level are reported
* Significant at the 99% level.

Figure 2 describes the distribution of working (market and non market) activities (in minutes) for the sample of households with both spouses participating to the labor market. It is striking the high percentage of men with zero value for home production, and as expected individual market working time in both cases peaks at 8 hours, the so-called "contract hours".

Finally, consider that for both partners market working time and home production are negatively correlated, however women's coefficient takes a much higher value (-0.8) compared to men's (-0.5).

Figure 2 Intra household allocation of time – Sample of two-earner households



## 6. Estimation results

### 6.1 Measuring individual domestic productivity

Following the theoretical analysis described in Sections 2 and 3 we carry out the estimation of individual domestic productivity by means of a two step procedure, which allows us to correct for sample selection bias, when we estimate time devoted to home production for the specific sub-sample of individuals that work on the labor market and produce domestic goods.

With respect to this issues men and women of the selected sample and in families from most western countries view the problem of time allocation from completely different perspectives. Women, given their domestic technology, their preferences for consumption and leisure and share of income, explicitly consider all the possible available options before making a choice on whether to work on the labour market and produce domestic goods. Instead men ultimately do not consider as an option paid work, but only domestic production. Such well-known stylised facts drive our research strategy to estimate individual domestic productivities following two distinct directions.

In particular, in order to estimate women domestic productivity we introduce a latent variable $I_f^*$ capturing, in reduced form, the joint female participation decision to the labor market and to domestic production. $I_f^*$ is defined as:

$$I_f^* = Y'd + X_f{}'g \tag{24}$$

where the vector $X_f$ contains a set of individual characteristics (age, education etc.) whereas $Y$ is a vector of household characteristics and $(d, g)$ are two coefficient vectors.

We also construct a dichotomous variable $I_f$ such that $I_f = 1 \Leftrightarrow I_f^* \geq 0$ and $I_f = 0 \Leftrightarrow I_f^* < 0$; this indicates the alternative chosen. Since Heckman (1979), we know that the full log-likelihood function of our model can be decomposed into the "selection model", where only the parameters $(d, g, \rho)$ are estimated, and a "conditional outcome model", which estimates the parameters vectors in (15) and the covariance matrix, holding $(d, g, \rho)$ fixed at the estimated values $(\hat{d}, \hat{g}, \hat{\rho})$. Given consistent estimators of $\left(\hat{d}, \hat{g}, \hat{\rho}\right)$ in the first stage, one can also obtain consistent estimators of the structural form in (15). In other words, our two-step estimation considers:

a. a preliminary estimation of a probit equation for the joint decision to participate to the labor market and spend a positive amount of time for domestic production, in reduced form;
b. the estimation of women time devoted to home production using the structural form (15) and controlling for selection bias involved in the simultaneous choice of working and producing domestic goods by including the inverse of the Mill's ratio $\lambda_f$, obtained from the first stage estimation.

Empirical estimates of the first step are presented in Table 4. Among the household characteristics included in the regression, the joint decision is mainly affected by a non linear function of age; also the higher is household non labor income the less likely the woman combines paid work with the domestic one. Instead a higher investment in education provides strong incentives for a woman to offer more work. Finally, playing the role of a demand factor for home production as an exclusive activity, the number of children has a discouraging impact, with an additional effect when they are 0-3 years old.

A result highlighted in Section 2 is that optimal time devoted to home production, when it is also efficient to offer paid work, is affected by individual characteristics only. Note that such property is valid regardless of the framework adopted (unitary or collective).

Results from the second step, i.e. the estimation of women time devoted to home production, are reported in Table 5. In support of the non-linear function of wage, derived from the marginal condition (10), both the estimated coefficients for $\overline{A}_f$ and $\gamma_f$ are consistent with a decreasing return to scale production function and satisfy the negative relation between the time devoted to domestic production and the wage rate. The intercept term $\pi_f / \overline{a}_f$ is instrumented with a polynomial function of age and three educational dummies. Women domestic productivity increases with age but at a decreasing rate, whereas lower education associates with lower domestic productivity, provided that the reference categories are higher degrees of schooling. A common negative constant term indicates a lower bound, i.e. a fixed cost, above which a positive value for domestic production can be obtained.

Table 4 The probability for a woman jointly participating to labor market and producing domestic goods

| Variables | | | |
|---|---|---|---|
| Woman's age | 0.422 | (0.077) | *** |
| Woman's age $^2$ | -0.005 | (0.001) | *** |
| Non labor income | -0.002 | (0.000) | *** |
| Man's Wage | -0.008 | (0.010) | |
| Woman Educational Dummies: Bac technique | 0.606 | (0.274) | ** |
| Bac +2 | 0.429 | (0.197) | ** |
| Univ. and post-grad. degree | 0.544 | (0.220) | *** |
| Number of children | -0.396 | (0.062) | *** |
| No. of children 0-3 years old | -0.499 | (0.158) | *** |
| Other adult | 0.291 | (0.385) | |
| City dummy: Paris | 0.091 | (0.168) | |
| Internet service at home | 0.592 | (0.263) | ** |
| Constant | -6.746 | (1.466) | *** |
| Obs. | | 612 | |
| | | Pseudo $R^2$ =0.22 | |

(***: $p \leq 0.01$; **: $0.01 < p \leq 0.05$; *: $0.05 < p \leq 0.10$)

Note: In the table results of a probit estimation and standard errors in brackets. Reference categories for categorical variables: women with a degree CAP/BEP or Bac general and not living in the capital.

Table 5 Estimation of women home production

| Variables | | | | |
|---|---|---|---|---|
| $\overline{A}_f$ | | 0.616 | (0.189) | *** |
| $\gamma_f$ | | 0.389 | (0.103) | *** |
| $\overline{B}_f$ | : Constant | -0.148 | (0.064) | ** |
| | Woman age | 0.010 | (0.003) | *** |
| | Woman age$^2$ | -0.000 | (0.000) | ** |
| | CAP/BEP school | -0.018 | (0.007) | *** |
| | Bac technique | 0.003 | (0.012) | |
| | Bac general | -0.034 | (0.011) | *** |
| $\lambda_f$ | | 0.016 | (0.011) | |
| $\sigma_\varepsilon$ | | 0.359 | (0.142) | *** |
| $\sigma_\eta$ | | 0.000 | (0.045) | |
| Obs. | | | 401 | |
| | | | $\log L$ =559.82 | |

Note: in the table results by ML estimation corrected for female participation to labor market and domestic production. Standard errors in parentheses. Reference category for categorical variables: Bac+2 and University and postgraduate degree.

Given the estimation of the error term $\varepsilon_{fj}$, each parameter of the production function can be derived, as already stated in Section 3. Results are contained in Table 6.

Table 6 Estimated coefficients of women home production function

| Variable | Mean | Std dev | Min | Max |
|---|---|---|---|---|
| $a_f$ | 22.613 | 8.536 | 6.877 | 51.508 |
| $\pi_f$ | 1.485 | 0.463 | -0.053 | 2.136 |
| $\gamma_f$ | 0.389 | 0.000 | 0.389 | 0.389 |

Table 6.a Estimated productivity and predicted wage rate: a comparison

| Variable | Mean | Std dev | Min | Max |
|---|---|---|---|---|
| $\pi_f$ | 1.485 | 0.463 | -0.053 | 2.136 |
| $\hat{w}_f$ | 8.232 | 1.044 | 6.473 | 11.224 |

Note: In the table results of the predicted values for the productivity term $\pi_f$ and the woman wage rate instrumented with the same demographic variables (a non linear function of age and three educational dummies). Correlation coefficient between the two variables 0.365.

We also investigate whether the estimated values for $\pi_f$ differ from the female wage rates: in particular, as a further check, we regress the latter on the same regressors used as instruments for $\pi_f$ and results reported in Table 6.a shows a high discrepancy and a low correlation coefficient.

As a sensitivity analysis, we also consider a more general model. In particular, instead of selecting only the sample of couples interviewed in week days, we also examine whether our model would determine how women in couple allocate their time between market work and home production during a whole week (week-end included).

Thus, let $h_f$ be the total hours of domestic production determined by the model, that is after equalizing the marginal product of hours of work with the wage rate. Consider two distinct values for $h_f$, depending on the day of the interview. Let then $h_f^{wd}$ be hours of work for those people observed during a weekday and $h_f^{we}$ hours of work of people observed during the week-end.

Provided that $h_f^{wd} = p \cdot h_f$ and $h_f^{we} = (1-p) \cdot h_f$, with $0<p<1$, then a generalization of the model described in (16) - when both samples are considered - would imply the following for observed hours, $h_f^o$:

$$h_f^o = \vartheta \cdot D \cdot \left\{ \overline{A} w_f \left( \frac{1}{\gamma - 1} \right) + \overline{B} + \varepsilon^{wd} \left[ \frac{\gamma}{\gamma - 1} \overline{A} w_f^{\frac{1}{\gamma - 1}} - \overline{B} \right] + \alpha \lambda_f + X' \beta + \eta^{wd} \right\} +$$

$$(1 - \vartheta) \cdot (1 - D) \cdot \left\{ \overline{A} w_f \left( \frac{1}{\gamma - 1} \right) + \overline{B} + \varepsilon^{we} \left[ \frac{\gamma}{\gamma - 1} \overline{A} w_f^{\frac{1}{\gamma - 1}} - \overline{B} \right] + \alpha \lambda_f + X' \beta + \eta^{we} \right\} \tag{25}$$

where $D$ is a dummy for being observed on a week-day and $\vartheta$ is a coefficient, capturing the probability $p$.

If a model of optimal week-time allocation as in (25) was a better representation for the household decision process, we would expect that women with a high salary should do less home production on week-ends, when they may have less constraint on their time.

However, results obtained estimating equation (25) by ML on a sample of 778 observations (401 couples interviewed on a week day and 377 over the weekend) were largely unsatisfactory.

A plausible explanation is that, due to the constraints set by the market, a worker with a high wage will do more paid work during the week– i.e. when the market is 'open'- and postpone more domestic work in the week-end. In other words, the model examined as first seems more appropriate, as it is derived under the assumption that the optimal allocation of time between paid and unpaid work is valid only on week-days, since the time to be spent on home production during week-ends cannot be determined by the wage rate; rather it should result from some optimal allocation between pure leisure and home production. Thus we found that the dichotomy between production and consumption examined in this study for working women breaks down during the weekend.

On the basis of such evidence, we can conclude that an additional hour of domestic production is traded with market time, for a constant leisure, only on weekdays as on average women cannot go to work on week-ends and cannot postpone all domestic consumption to week-ends either. Overall, we consider this result as further evidence supporting our model of efficient allocation between home production and market working time during a week, but excluding the weekend.

Before discussing results from the labor supply estimation, we briefly raise the issue of the lack of evidence found for men domestic production. Several attempts made with various sophisticated models (as a non linear tobit model) were unable to find convincing results. Thus we can only conclude that time devoted to home production by men is only randomly chosen after their working time has been fixed by contract. As a consequence we are not in the position to estimate men domestic productivity $\pi_m$ by means of the INSEE time use survey and we consider is as a random component in the production function.

**6.2 The estimation of labor supply**

In what follows we present the estimation results of the household labor supply, using two alternative measures of working time as dependent variable, specifically:

a) individual market labor time, measured in minutes spent in paid work during a day, as it is commonly done in standard literature;
b) total labor supply, as the sum of market labor time and time devoted to home production.

A well-known drawback of market labor supply estimations run especially with European survey data is that due to the rationing imposed by labor contracts, they usually do not seem to respond significantly to wages and income. This is particularly relevant for men labor supply (see Pencavel, 1986 for a survey). As a consequence, an interesting exercise is to investigate whether the same result holds true also when working time does include time hours in home production.

In either case, we estimate the household labor supply by full information maximum likelihood (FIML), which provides efficient estimates of the parameters of simultaneous equations, since it can handle both plausible correlation between the error terms in the male and female labor supply and heteroskedasticity in the errors in an unknown form.

Another relevant consideration is that wage rates, and non-labor income, entering in the household labor supply system, are not exogenous to hours of work. There are various reasons for considering the two sets of variables as endogenous; in particular, for the wage rate, one should consider the so-called “division bias”, since it is a derived variable (yearly after-tax labor earnings divided by the product of working weeks per year and working hours per week), and also the presence of unobservable components (e.g., preferences for work) which might influence both wages and hours. Moreover, even individual non-labor income could include endogenous components, as, for instance, it might well be derived from labor income savings.

In order to overcome the potential endogenity problem, all variables are accurately instrumented with exogenous socio-demographic variables (individual age and educational level, also interacted), number of children with an additional effect when they are 0-3 years old, the presence of another adult co-residing, living in the city of Paris and an internet link provided in the house (see final Appendix for results)[5].

Following system (17), each labor supply equation also includes personal age in an exponential form, educational dummies and the presence of children 0-3 years old. Finally, female labor supply is corrected for selection bias, by adding in the labor supply equation the inverse of the Mills' ratio ($\lambda_w$) obtained from a previous estimation of her participation to the labor market (see Table 3.a in the Appendix); we use as extra identifying variables for women participation three regional dummies (detecting the household residence in the North, West, or Central- East of the country).

Table 7 lists coefficients and asymptotic standard errors obtained from the estimation of market labor time, in the first column, and of total labor supply in the second. As expected, we find a very low significance level in male market labor supply, which seems rigidly fixed at a constant level. The significance level improves in estimating women market labor supply, which is affected by unearned income not only directly, but also when interacted with family wages. Also female domestic productivity has a significant negative impact on her own market labor supply, as evidence of a substitution effect prevailing; this result is also consistent with the negative correlation between market working time and home production found in the data description. The significance of $\lambda_w$ confirms that the sub-sample selected of working wife is not randomly drawn, although it has an unexpected negative sign.

[5] Individual wage estimates were not corrected for selection bias, as a preliminary investigation did not provide a better fit.

Table 7: The household labor supply system: the unrestricted model

| MEN | Market labor supply | Total labor supply |
|---|---|---|
| $\log \hat{w}_m$ | -0.551 (2.658) | -4.131 (2.615) * |
| $\log \hat{w}_f$ | 0.165 (2.063) | -1.600 (2.031) |
| $\hat{\hat{y}}$ | 0.024 (0.126) | -0.071 (0.124) |
| $\log \hat{w}_m \times \log \hat{w}_f$ | -0.294 (0.854) | 0.770 (0.841) |
| $\log \hat{w}_m \times \hat{\hat{y}}$ | 0.016 (0.049) | 0.006 (0.048) |
| $\log \hat{w}_f \times \hat{\hat{y}}$ | -0.028 (0.090) | 0.028 (0.088) |
| $\hat{\pi}_f$ | 0.265 (0.319) | -0.608 (0.314) ** |
| Man's age | 0.090 (0.142) | 0.429 (0.139) *** |
| Man's age $^2$ | -0.001 (0.002) | -0.004 (0.001) *** |
| Bac general | 0.692 (0.553) | 0.736 (0.544) |
| Bac +2 | 0.908 (0.627) | 1.258 (0.617) ** |
| Univ. degrees | 1.661 (0.933) * | 1.959 (0.915) ** |
| Child 0-3 years old | -0.133 (0.274) | 0.548 (0.269) ** |
| Constant | 7.917 (5.127) | 9.140 (5.047) * |
| **WOMEN** | **Market labor supply** | **Total labor supply** |
| $\log \hat{w}_m$ | 0.464 (2.208) | -0.526 (1.806) |
| $\log \hat{w}_f$ | 0.997 (2.380) | 0.450 (1.946) |
| $\hat{\hat{y}}$ | -0.307 (0.146) ** | -0.314 (0.119) *** |
| $\log \hat{w}_m \times \log \hat{w}_f$ | -0.365 (0.942) | -0.256 (0.770) |
| $\log \hat{w}_m \times \hat{\hat{y}}$ | -0.151 (0.057) *** | -0.094 (0.046) *** |
| $\log \hat{w}_f \times \hat{\hat{y}}$ | 0.346 (0.104) *** | 0.268 (0.085) *** |
| $\hat{\pi}_f$ | -1.733 (0.511) *** | -0.076 (0.418) |
| Woman's age | 0.070 (0.028) *** | 0.040 (0.023)* |
| Bac technique | 0.645 (0.449) * | 0.120 (0.366) |
| Bac general | -0.464 (0.505) | -0.502 (0.412) |
| Bac +2 | 0.302 (0.314) | -0.019 (0.255) |
| Child 0-3 years old | 0.484 (0.355) | -0.363 (0.290) |
| Constant | 6.458 (5.267) | 10.158 (4.308) ** |
| $\lambda_w$ | -1.726 (0.461) *** | -0.448 (0.376) |
| | *LogL*= -1595.078; $\rho$=0.29 | *LogL*= -1508.527; $\rho$=0.31 |

Note: FIML estimates of two simultaneous equation by semi-log household labor supply: sample of two earner couples (397 obs.). Each regression includes a correlation between the errors ($\rho$).

Table 8 The unrestricted vs. the collective model of household total labor supply

| MEN | Unrestricted system | Collective Model |
|---|---|---|
| $\log \hat{w}_m$ | -4.131 (2.615) * | -1.392 (1.241) |
| $\log \hat{w}_f$ | -1.600 (2.031) | 0.014 (0.628) |
| $\hat{\hat{y}}$ | -0.071 (0.124) | -0.071 (0.156) |
| $\log \hat{w}_m \times \log \hat{w}_f$ | 0.770 (0.841) | -0.061 |
| $\log \hat{w}_m \times \hat{\hat{y}}$ | 0.006 (0.048) | -0.021 (0.043) |
| $\log \hat{w}_f \times \hat{\hat{y}}$ | 0.0277 (0.088) | 0.060 |
| $\hat{\pi}_f$ | -0.608 (0.314) ** | -0.053 |
| Man's age | 0.429 (0.139) *** | 0.287 (0.127) ** |
| Man's age $^2$ | -0.004 (0.001) *** | 0.003 (0.002) ** |
| Bac general | 0.736 (0.544) | 0.574 (0.516) |
| Bac +2 | 1.258 (0.617) ** | 0.866 (0.559) |
| Univ. degrees | 1.959 (0.915) ** | 1.485 (0.875) * |
| Child 0-3 years old | 0.548 (0.269) ** | 0.576 (0.270) ** |
| Constant | 9.140 (5.047) * | 6.403 (2.474) *** |
| **WOMEN** | **Unrestricted system** | **Collective Model** |
| $\log \hat{w}_m$ | -0.526 (1.806) | -0.481 (1.847) |
| $\log \hat{w}_f$ | 0.450 (1.946) | 0.499 (1.973) |
| $\hat{\hat{y}}$ | -0.314 (0.119) *** | -0.311 (0.120) *** |
| $\log \hat{w}_m \times \log \hat{w}_f$ | -0.256 (0.770) | -0.271 (0.790) |
| $\log \hat{w}_m \times \hat{\hat{y}}$ | -0.094 (0.046) *** | -0.091 (0.050) * |
| $\log \hat{w}_f \times \hat{\hat{y}}$ | 0.268 (0.085) *** | 0.263 (0.090) *** |
| $\hat{\pi}_f$ | -0.076 (0.418) | -0.233 (0.598) |
| Age | 0.040 (0.023)* | 0.048 (0.030) * |
| Bac technique | 0.120 (0.366) | 0.177 (0.373) |
| Bac general | -0.502 (0.412) | -0.629 (0.477) |
| Bac +2 | -0.019 (0.255) | 0.008 (0.262) |
| Child 0-3 years old | -0.363 (0.290) | -0.361 (0.292) |
| Constant | 10.158 (4.308) ** | 9.946 (4.340) ** |
| $\lambda_w$ | -0.448 (0.376) | -0.460 (0.376) |
| | *LogL*= -1508.527; $\rho$=0.31 | *LogL*= -1510.8693; $\rho$= 0.33 |

Note: FIML estimates of two simultaneous equation. Semi-log system of household total labor supply: sample of two earner couples (397 obs.). Coefficients without standard error are constrained.

Table 9 Likelihood ratio test

| | Unrestricted Model | Collective Model |
|---|---|---|
| *log L* | -1508.527 | -1510.869 |
| LR (dof) | - | 4.685 (3) |

Note: Sample of households with both spouses working

The quality of the estimations improves when moving to total labor supply. In particular, the husband's one is affected negatively by his own wage rate and by a few demographic variables (in particular age, age squared, having a child 0-3 years old and higher educational dummies). The significance of the female domestic productivity term in the male labor supply equation already provides sufficient evidence against the traditional unitary model, as it has been clarified in Section 2 and 3.

Conversely, the woman's total working hours are affected by nearly all the variables influencing her market labor supply, except for the domestic productivity and the $\lambda_w$ terms.

Table 8 contains in the second column the parameter estimates of the collective system of total labor supply, i.e. once restrictions (18) are imposed, whereas the first column reports the estimates of the unrestricted model, already presented in the previous table, to facilitate a comparison. Overall signs and significance level are confirmed, also when the necessary collective restrictions hold.

Table 9 compares the log-likelihood values obtained from the estimation of system (21), unrestricted and with the restrictions derived in section 1, and reports the derived likelihood ratio statistics. On the basis of the evidence found, the three restrictions imposed by the collective model cannot be statistically rejected (LR test $\chi^2_{(3)}$ =4.685).

Empirical results from the estimation of the collective model is completed with the computation of the parameters and the asymptotic standard errors (obtained by the 'delta method') of the income sharing rule (see Table 10). The sign of the coefficients of the income sharing rule and of the partials are reported in the second column. They imply that an increase in the husband's wage rate tends to reduce substantially his transfer to the wife, as well as an increase in the wife's wage rate, although the effect is smaller. These results suggest that women of our sample behaves more altruistically than men. An opposite result is instead found for changes in total unearned income: 100 € increase in non labor income will increase the wives' share by about 70 percent. So far, the signs of the income sharing rule parameters are consistent with those found by CFL, although our results have a higher significance level.

The novelty of our approach allows us to measure the effect of female domestic productivity on the intra-household allocation of resources. According to our estimates, given an average productivity value of 1.485, a family with a one percentage increase in female domestic productivity would see men benefiting of 10.21 € increase in his total income share.

Table 10 Sharing rule estimates

| | Coefficients | $\partial\phi_m / \partial$Variable |
|---|---|---|
| Log $\hat{w}_m$ | 1421.90 (457.48) *** | 333.75 (221.34)† |
| log $\hat{w}_f$ | -189.00 (171.83) | 98.48 (120.33) † |
| $\hat{\hat{y}}$ | 919.53 (367.47)*** | -71.97 (103.75) |
| $\hat{\pi}_f$ | 687.53 (318.26) ** | 687.53 (318.26) ** |
| Log $\hat{w}_m \times$ log $\hat{w}_f$ | 798.06 (342.45) *** | - |
| Log $\hat{w}_m \times \hat{\hat{y}}$ | 269.09 (198.88) | - |
| log $\hat{w}_f \times \hat{\hat{y}}$ | -775.90 (337.72) ** | - |

Note: Sample of households with both spouses working. Asymptotic standard errors, computed by delta method, in brackets.
† The derivatives are computed with respect to $\hat{w}_m$ and $\hat{w}_f$, respectively.

Table 11 Labor supply elasticities

| | *Market labor supply* | *Total labor supply* | |
|---|---|---|---|
| | Unrestricted Model | Unrestricted Model | Collective Model |
| Men | | | |
| Log $\hat{w}_m$ | -0.309 (0.721) | -0.587 (0.605) | -0.356 (0.276) |
| log $\hat{w}_f$ | -0.130 (0.510) | 0.035 (0.429) | -0.013 (0.091) |
| $\hat{\hat{y}}$ | 0.000 (0.022) | 0.000 (0.018) | 0.001 (0.002) |
| Women | | | |
| Log $\hat{w}_m$ | -0.135 (0.161) | -0.263 (0.099)*** | -0.259 (0.099) *** |
| log $\hat{w}_f$ | 0.147 (0.158) | 0.031 (0.097) | 0.033 (0.097) |
| $\hat{\hat{y}}$ | 0.009 (0.003) *** | 0.003 (0.002) | 0.003 (0.002) |

Note: Sample of households with both spouses working. Asymptotic standard errors, computed by delta method, in brackets.

What are the policy implications of adopting the collective perspective on total rather than market labor supply, as specified in this paper? The answer is provided by comparing the uncompensated labor supply elasticities to changes in individual wage rates and non-labor income using the two measures and after imposing the collective restrictions (see Table 11). Even though the signs are in most of cases similar, the dimension of the effect substantially differs in a few cases. As far as the collective specification is concerned, we obtain a negative uncompensated wage elasticity for the husband, showing a dominant income effect, and a small but positive value for wife, showing a prevailing substitution effect. This evidence is consistent with previous international evidence on market labor supply (see Pencavel, 1986), although the female uncompensated wage elasticity for total labor hours seems less sensitive to the wage rate compared also to the value estimated with market labor hours. Moreover we find that the household total labor supplies are complementary, this is particularly evident in the female supply. Finally the collective framework detects similar elasticities to non-labor income: for both men and women the value is positive and rather small.

To sum up the main empirical results: the implementation of the likelihood ratio test, the derivation of the parameters involved in the model, and the estimation of the labor supply elasticities are all consistent in highlighting the need for more sophisticated intra-household decision models, that take account of the individual domestic productivity as a distributional factor in the within household resource allocation process.

## 7. Conclusion

In this paper we developed a new technique that allows to estimate individual domestic productivity when both couple members work on the labor market.

An interesting finding is that domestic productivity is an independent determinant of labor allocation even for women who may have equalized their marginal product at home and on the market.

Our work was also devoted to testing whether a collective model of total labor supply is a better representation of intra-household decision over working/leisure time. According to our estimates, we cannot reject the collective model as above specified.

We reckon however that our analysis is subject to few limitations and that opens up future directions for research. In particular, our analysis excludes consumption of non- marketable domestic goods.

The invalidation of the recusivity property for couples with a non working woman limits our identification technique to two earner couples only.

Finally, the fact that the choice of market working hours is so heavily constrained in France might well have introduced noise in the whole exercise. In this respect repeating the estimates with survey from countries with a more flexible labor market could provide a useful sensitivity measure.

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## Appendix 1

In order to write down the log likelihood function, we generalise (15) considering a non-linear model with heteroskedasticity, as it follows:

$$h_{ij} = k(\delta, x_j) + \varepsilon_j g(\delta, x_j) + \eta_j \qquad \text{with } j = 1, .., n \text{ and } i = m,f \qquad \text{(A.1).}$$

where $\delta$ is the vector of coefficients and $x$ a vector of variables, including individual demographic characteristics $X_i$, and individual wage rate.

Furthermore, it follows that (A.1) can be written in a more compact form as:

$$h_{ij} = k(\delta_j, x_j) + u_j \qquad \text{with} \qquad u_j \approx N\left(0, \sqrt{\sigma_\varepsilon^2 g^2(\delta, x_j) + \sigma_\eta^2}\right)$$

and $u_j$ being independent across observations.

Onwards, we use the following simplifications in the notation (with $j = 1, .., n$):

$$k_j = k(\delta, x_j); \qquad g_j = g(\delta, x_j); \qquad s_j^2 \approx \sigma_\varepsilon^2 g^2(\delta, x_j) + \sigma_\eta^2$$

We are now able to compute the likelihood function of a sample ($h_{ij}$, $x_j$). It comes immediately that the likelihood of an observation is given by :

$$V_j = \frac{1}{\sqrt{2\pi s_j}} Exp\left[-\frac{(h_{ij} - k_j)^2}{2s_j^2}\right]$$

and, for the whole sample, the log likelihood is:

$$LogL(\delta, \sigma_\varepsilon, \sigma_\eta) = -\frac{n}{2}\log(2\pi) - \frac{1}{2}\sum_j \log(s_j^2) - \frac{1}{2}\sum_j \log\frac{(h_{ij} - k_j)^2}{s_j^2} \qquad \text{(A.2)}$$

From expression (A.2) the vector of the gradient of the likelihood derives.

Finally, the estimation of model (A.2) by ML will provide a full set of estimates, including $\delta$ the vector of coefficients and $\varepsilon_j$, which from total residual $u_j = \varepsilon_j g(\cdot) + \eta_j$ will be given by the following condition:

$$\hat{\varepsilon}_{ij} = E\left[\varepsilon_{ij} \middle| \varepsilon_{ij} g(\cdot) + \eta_{ij} = \hat{u}_{ij}\right]$$

knowing that $Cov[\varepsilon_i, \eta_i] = 0$.

## Appendix 2

Table 1.a Estimation of household non labor income

| Variables | | | |
|---|---|---|---|
| Constant | 541.989 | (108.985) | *** |
| Man's age | -32.166 | (5.677) | *** |
| Man's age $^2$ | 0.440 | (0.070) | *** |
| Man educational dummies: Bac technique | 32.349 | (19.076) | * |
| Bac general | 17.565 | (19.353) | |
| Bac +2 | 151.806 | (112.593) | |
| Man's age × Bac +2 | -3.160 | (2.616) | |
| Man's age × Univ., post-grad. degree | -0.450 | (0.440) | |
| No. of children | 37.767 | (4.219) | *** |
| No. of children 0-3 years old | 11.642 | (15.461) | |
| Other adult | 79.812 | (36.423) | *** |
| City dummy: Paris | 17.186 | (16.952) | |
| Internet service at home | 12.388 | (22.800) | |
| Obs. | | 1262 | |
| | $R^2$=0.14 | | |

Note: in the table results by OLS estimates and robust standard errors in brackets. Reference category for categorical variables: CAP/BEP educational dummy and not living in the capital.

Table 2.a Estimation of men wage rate (in logs)

| Variables | | | |
|---|---|---|---|
| Constant | 2.966 | (0.279) | *** |
| Man's age | 0.057 | (0.014) | *** |
| Man's age$^2$ | -0.001 | (0.000) | *** |
| Man educational dummies: Bac general | 0.246 | (0.038) | *** |
| Bac +2 | -0.147 | (0.148) | |
| Univ., post-grad. degree | 0.018 | (0.199) | |
| Man's age × Bac +2 | 0.014 | (0.004) | *** |
| Man's age × Univ., post-grad. degree | 0.017 | (0.005) | *** |
| No. of children | -0.008 | (0.009) | |
| No. of children 0-3 years old | 0.003 | (0.025) | |
| Other adult | -0.121 | (0.072) | * |
| City dummy: Paris | 0.049 | (0.028) | * |
| Internet service at home | 0.172 | (0.044) | *** |
| Obs. | | 1344 | |
| | $R^2$ =0.43 | | |

Note: in the table results by OLS estimates and robust standard errors in brackets. Reference category for categorical variables: CAP/BEP or Bac technique educational dummy, not living in the capital.

Table 3.a Estimation of women wage rate (in logs)

| Variables | | | |
|---|---|---|---|
| Constant | 3.073 | (0.298) | *** |
| Woman's age | 0.046 | (0.016) | *** |
| Woman's age$^2$ | -0.001 | (0.000) | *** |
| Woman educational dummies: CAP/ BEP school | 0.004 | (0.026) | |
| Bac +2 | -0.023 | (0.128) | |
| Univ., post-grad. degree | 0.107 | (0.213) | |
| Woman's age × Bac +2 | 0.012 | (0.003) | *** |
| Woman's age × Univ., post-grad. degree | 0.017 | (0.006) | *** |
| No. of children | -0.035 | (0.015) | *** |
| No. of children 0-3 years old | 0.102 | (0.030) | *** |
| Other adult | -0.102 | (0.062) | * |
| City dummy: Paris | 0.143 | (0.032) | *** |
| Internet service at home | 0.109 | (0.0429) | *** |
| Obs. | | 1089 | |
| | $R^2$ =0.37 | | |

Note: in the table results by OLS estimates and robust standard errors in brackets. Reference category for categorical variables: Bac general or Bac technique educational dummy and not living in the capital.

Table 4.a Estimation of women participation to the labor market

| Variables | | | |
|---|---|---|---|
| Constant | -5.224 | (1.369) | *** |
| Non labor income | -0.001 | (0.000) | *** |
| Woman's age | 0.344 | (0.070) | *** |
| Woman's age$^2$ | -0.004 | (0.001) | *** |
| Woman educational dummies: Bac technique | 0.589 | (0.262) | ** |
| Bac +2 | 0.303 | (0.970) | |
| Univ., post-grad. degree | 0.250 | (0.793) | |
| Woman's age × Bac +2 | 0.007 | (0.024) | |
| Woman's age × Univ., post-grad. degree | -0.006 | (0.021) | |
| No. of children | -0.410 | (0.059) | *** |
| No. of children  0-3 years old | -0.519 | (0.155) | *** |
| Other adult | 0.242 | (0.378) | |
| City dummy: Paris | 0.163 | (0.166) | *** |
| Internet service at home | 0.627 | (0.256) | *** |
| Geographical dummies: Central East | 0.264 | (0.198) | |
| West | 0..348 | (0.154) | ** |
| North | -0.171 | (0.207) | |
| Obs. | | 674 | |
| | Pseudo $R^2$=0.21 | | |

Note: in the table results by probit estimates and asymptotic standard errors in brackets. Reference category for categorical variables: CAP/ BEP school or Bac general educational dummy and not living in the capital, but residing in the Centre, or South-west, Parisian region or Mediterranean regions.